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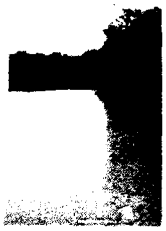

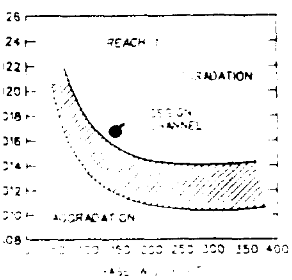

HYDRAULICS
LABORATORY

MISCELLANEOUS PAPER HL-91-2

SEDIMENT ASSESSMENT OF SOUTH BRANCH POTOMAC RIVER, AT PETERSBURG WEST VIRGINIA

by

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US ARMY ENGINEER WATERWAYS EXPERIMENT STATION

May 1991

Final Report

Approved For Public Release; Distribution Unlimited

Prepared for US Army Engineer District, Baltimore
Baltimore, Maryland 21203-1715

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	May 1991	Final report

4. TITLE AND SUBTITLE

Sediment Assessment of South Branch, Potomac River, at Petersburg, West Virginia

5. FUNDING NUMBERS

6. AUTHOR(S)

Nolan K. Raphelt

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

USAE Waterways Experiment Station, Hydraulics Laboratory, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199

8. PERFORMING ORGANIZATION REPORT NUMBER

Miscellaneous Paper HL-91-2

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

USAE District, Baltimore, PO Box 1715, Baltimore, MD 21203-1715

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

A sedimentation study of a local flood protection project on the South Branch of the Potomac River at Petersburg, WV, was conducted. The investigation represented a sediment assessment level study conducted to test for potential sedimentation problems. Project features for the proposed project included raising existing levees adjacent to the town of Petersburg and adding levees both upstream and downstream from the existing levees and on the opposite side of the river from the existing levees. The approach included the use of a sediment budget analysis to test for deposition of sand and gravel and a field reconnaissance to evaluate overall stability of the existing channel. The sediment assessment is suggested in EM 1110-2-4000, "Sedimentation Investigations of Rivers and Reservoirs," for use in early stages of project formulation such as the reconnaissance stage to help identify potential sediment problems. The assessment technique used in this study is a software package for a personal computer titled Hydraulic Design of Flood Control Channels, generally

(Continued)

14. SUBJECT TERMS		15. NUMBER OF PAGES
Flood protection	Sediment assessment	31
Levees	Sedimentation	16. PRICE CODE
SAM		

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED		

13. ABSTRACT (Continued).

referred to as SAM. The SAM assessment indicated that the project will be subject to some aggradation during the 25-year and larger floods. However the amount of aggradation should not be severe enough to affect project integrity. The local sponsor should monitor the channel, including approach and exit reaches, by periodic resurveys of established sediment ranges.

Preface

The work described herein was conducted and this report was prepared at the US Army Engineer Waterways Experiment Station (WES) at the request of the US Army Engineer District, Baltimore (CENAB).

This investigation was conducted during the period January 1990-June 1990 in the Hydraulics Laboratory of WES under the direction of Messrs. Frank A. Herrmann, Jr., Chief of the Hydraulics Laboratory; R. A. Sager, Assistant Chief of the Hydraulics Laboratory; Mr. Marden B. Boyd, Chief of the Waterways Division, Hydraulics Laboratory; and Mr. Michael J. Trawle, Chief of the Math Modeling Branch, Waterways Division. The project was conducted and the report prepared by Mr. Nolan K. Raphelt, Math Modeling Branch.

Commander and Director of WES during preparation of this report was COL Larry B. Fulton, EN. Technical Director was Dr. Robert W. Whalin.

Contents

Conversion Factors, Non-SI To SI (Metric) Units of Measurement

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
cubic feet	0.02831685	cubic metres
cubic yards	0.7645549	cubic metres
feet	0.3048	metres
miles (US statute)	1.609344	kilometres
pounds (force) per square foot	47.88026	pascals
tons (2,000 pounds, mass)	907.1847	kilograms

SEDIMENT ASSESSMENT OF SOUTH BRANCH, POTOMAC RIVER, AT PETERSBURG, WEST VIRGINIA

Approach

1. This report describes a "sediment impact assessment" level of sediment study conducted to test for potential sedimentation problems. The approach uses a sediment budget analysis to test for deposition of sand and gravel and, in this case, a field reconnaissance to look for erosion problems. The sediment impact assessment is proposed in Engineer Manual (EM) 1110-2-4000* for use in the early stages of project formulation such as the reconnaissance stage to help identify potential sediment problems.

Available Field Data

2. Available field data for this study include a flow-duration curve, an annual peak discharge curve for the South Branch Potomac River at Petersburg, 17 cross sections for South Branch Potomac River (Figure 1), and three bed gradation curves for the South Branch Potomac River. All of the data used in this report were furnished by the Baltimore district. The gradation curves are shown in Figure 2. The flow-duration relationship is shown in Table 1 and the annual peak-duration relationship is shown in Table 2. No sediment concentration measurements were available for this study.

Site Reconnaissance

3. Site reconnaissance was made of the South Branch of the Potomac River in March 1989. This reconnaissance revealed that the river is the typical mountain stream that one would expect in the mountains of West Virginia. The stream had a gravel and small cobble bed with occasional small areas of sand exposed. The exposed sand was found behind bridge piers and at other areas where some obstruction prevents the movement of gravel and cobbles into

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* US Army Corps of Engineers. 1989 (15 Dec). "Sedimentation Investigations of Rivers and Reservoirs," EM 1110-2-4000, US Government Printing Office, Washington, DC.

the area. The project this sediment impact assessment addresses includes raising some existing levees adjacent to the river that protect the town of Petersburg, West Virginia, and adding levees both downstream from the existing levees and on the opposite side of the river from the existing levees. In addition to becoming familiar with the project area the field reconnaissance objectives were to determine if the existing channel showed signs of aggradation, degradation, or excessive bank caving and to determine land use within the basin.

Aggradation in the project reach

4. The present channel at Petersburg did not show any obvious aggradation trends. The channel was not perched and no defined low water channels were observed. Dennis Seibel, Chief of Hydraulics, US Army Engineer District, Baltimore, stated the channel had been cleaned out after a disastrous flood that occurred in November 1985. This flood overtopped the existing levees and deposited material in the channel upstream from Highway 220 bridge, which is located between cross sections 8 and 9 (Figure 1). The Soil Conservation Service performed the channel cleanout after the flood; however, they did not survey cross sections before or after the channel work. Without such surveys, it is difficult to determine for certain whether or not channel aggradation is occurring in the project reach.

Degradation in the project reach

5. No degradation trends were found in the existing channel inverts during the field trip.

Land use in the basin

6. The land use in Petersburg is residential and business areas on the left descending bank and a small industrial park and airport on the right bank. Upstream from Petersburg, the land use includes some agricultural grazing lands, but is primarily forested mountain terrain.

Bank erosion

7. For the most part, channel banks were low and appeared to be stable. At one location in the residential area between cross sections 15 and 16 (Figure 1), some bank caving was observed. This bank erosion did not appear to be significant enough to affect the proposed project, although monitoring of this bank should be continued.

Estimating Possible Deposition in Project Channel

The method

8. The potential for deposition is estimated by using a sediment budget analysis for the sand and gravel sized sediments. In the general case the sediment budget approach is a comparison between the annual sediment yield from the existing channel and the annual sediment yield from the project channel. In this case the annual sediment yield was not measured, requiring that sediment transport be calculated with appropriate transport theory. The sediment discharge rating curve was then plotted for both the existing and the project conditions. Those rating curves were then integrated with a flow-duration curve to obtain annual sediment yield for both existing and project conditions. The two annual sediment yields were used to calculate a trap efficiency, which is a measure of the ability of the project channel to carry the historical sediment load. That procedure for calculating annual yield is referred to as the Flow-Duration Sediment-Discharge Rating Curve Method in EM 1110-2-4000.*

Data required for assessment

9. This procedure requires watershed data, channel geometric data, bed-sediment gradation data, hydrologic data, and hydraulic data.

Watershed data

10. The drainage area for the South Branch Potomac River at Petersburg is 642 square miles.**

Geometric data

11. The basic geometry was read from HEC-2 data files furnished by Baltimore District for both existing and project channels.

Hydrology data

12. Flow-duration data. The flow-duration data, furnished by Baltimore District, were used for both existing and project conditions (Table 1).

13. Single-event hydrographs. No single-event hydrographs were available for the South Potomac River at Petersburg.

14. Hypothetical flood peaks. The annual peak discharges for hypothetical frequencies, furnished by the Baltimore District, were used in this

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* Op. cit.

** A table of factors for converting non-SI units of measure to SI (metric) units is found on page 3.

sediment assessment for both existing and project conditions (Table 2).

Hydraulic data

15. Water velocity, depth, width and slope were calculated using a new computer program package, SAM, being developed under the research program, Flood Control Channels. That method calculates the bed roughness using the Limerinos bed roughness predictor equation for the movable-bed portion of the cross section.* These individual roughness values are then composited with n values, calculated from Ks (equivalent roughness factor) for bank and vegetation roughness, using the alpha method, and a normal depth solution is made to determine the hydraulic parameters for the sediment transport calculations for the inflowing section, the existing channel and the project channel respectively. The sediment rating curve and annual sediment yield were determined at two locations along the project channel. Cross sections 10 and 11.5 were used for the analysis. Cross section 10 was used because it is located in the reach of the channel that will have levees on both sides of the river and has a significant increase in channel velocities. Cross section 11.5 was chosen because it is located in an upstream reach of the river that receives significant backwater effects during major flood events (Figure 3). This backwater effect causes an increase in stages which results in decreased velocities and energy gradients (Figure 4). Stage discharge relations for cross sections 10 and 11.5 are shown on Figures 5 and 6.

Sediment transport calculations

16. The sediment load was calculated using the Meyer-Peter-Muller function for bed material transport.** Bed gradation curve 5, shown in Figure 2, was used in the sediment transport calculations. This bed gradation was used because during the site reconnaissance, it appeared to be the most representative sample of the channel bed in and upstream of the study reach.

Inflowing sediment discharge rating curve

17. Cross section number 17 (Figure 1) was used to calculate the inflow sediment load. This cross section is located in what appears to be a stable section of channel and the existing and project channel flow lines are equal

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* J. T. Limerinos. 1970. "Determination of the Manning Coefficient from Measured Bed Roughness in Natural Channels," USGS Water-Supply Paper 1989-B, US Geological Survey, Reston, VA.

** Meyer-Peter, E., and Muller, R. 1948. "Formulas for Bed Load Transport," *Report on Second Meeting of International Association for Hydraulic Research*, Stockholm, Sweden, pp 39-64.

at this cross section; therefore, the project will have no effect on the ment transport potential at this cross section. This cross section is cl enough to the project that it is reasonable to assume that sediment passi this cross section will have to be transported through the proposed levee reach of the river. Results of the sediment transport computations for t reach of the river are shown on Table 3 and plotted versus water dischar Figure 7.

Sediment transport in the existing channel

18. Results of the sediment transport computations for existing co tions for cross sections 10 and 11.5 are shown on Table 4 and plotted ve water discharges in Figures 8 and 9. Using the flow-duration data, the lated annual volume that cross section 10 can transport is 14,258 cubic Cross section 11.5 can transport 13,474 cubic yards annually.

Sediment transport in the project channel

19 The proposed project design channel was evaluated at cross se tions 10 and 11.5. The calculated sediment discharges are shown in Tabl and are plotted versus water discharges on Figures 10 and 11.

Sediment budget analysis

20. The calculated sediment yield into the proposed leveed reach South Branch Potomac River at Petersburg, West Virginia, is 12,255 cubic per year using the flow durations in Table 1. The calculated annual vol that the project channel can transport at cross section 11.5 is 13,457 c yards per year and the calculated annual volume at cross section 10 is 14,269 cubic yards. That results in trap efficiency from cross section cross section 11.5 or -9 percent and trap efficiency from cross section to 10 of -6 percent. The small negative trap efficiency indicates that channel should not be subject to general deposition trends, but could e ence a minor amount of degradation. To determine if significant channe radation could be expected, the transport capacity of the project chann compared to the existing channel at cross sections 10 and 11.5. The pr channel in the range of the flow-duration curve, i.e., the flows consid sediment budget analysis, has the same hydraulic parameters as the exis channel. Because the existing channel does not indicate a tendency to grade, any significant degradation of the project channel at flows belo 30,000 cfs would not be expected.

Sediment rating curve analysis

21. The Sediment Budget Analysis provides a means for analyzing how the channel will react to the normal or average flow experienced by the channel. The higher flood events, such as the November 1985 flood, have such a short duration that they are not accurately modeled using a duration analysis. The peak mean daily flow of 77,000 cfs lasted one day, and therefore the 77,000 cfs flow historically has been equaled or exceeded 0.005 percent of the time for the period of record for this gage (1928-1986). The backwater effect caused by levees on both sides of the river during higher flows results in a significant decrease in the sediment transport capacity of cross section 11.5 (Figure 11). Because of this loss of capacity, if a mean daily flow of 77,000 cfs occurs again, it should be expected that at least 17,000 tons of material will deposit in the channel. During a 50-year discharge of 61,600 cfs it should be expected that about 13,000 tons of sediment will be deposited. During the 25-year discharge (47,900 cfs), about 8,500 tons of deposited material may be expected. This material would most likely be deposited in the channel and overbank areas between cross sections 11 and 13 (Figure 1) because of the backwater effect in this reach.

Single-event analysis

22. The hydrology necessary to develop a 100-year or SPF Flood Hydrograph has not been developed. A single-event sediment transport analysis should be done prior to the construction of the proposed project. This analysis should be performed on the hydrograph that produces the design discharge.

Erosion Protection Analysis

23. The Baltimore District will conduct an erosion protection analysis for the Petersburg Project.

Approach Channel

24. The approach channel refers to that section of the river starting at the project boundary and continuing upstream. There have been occurrences of erosion at such a junction as well as cases where flood waters bypassed the project channel. For this discussion, the approach channel refers to cross sections 13 and greater (Figure 1). In this case the historical

stage-discharge rating curve is maintained in the approach channel. Because the hydraulics of the approach are not affected by this project, the approach channel should not be subject to either project induced aggradation or degradation. As stated earlier in this assessment, field reconnaissance indicated that the left bank area between cross sections 15 and 16 is experiencing a minor amount of bank caving. This section of the channel should be monitored to insure that the designed channel alignment is maintained.

Exit Channel

25. The exit channel of the project is the South Branch of the Potomac River downstream of Petersburg. Field trip observations of the exit channel revealed a very stable channel that should not be adversely affected by the operations and maintenance of the proposed project.

Lateral Inflow Points

26. All lateral inflows into the project are being routed around the levee area and will enter the river downstream of the proposed project.

Conclusions and Recommendations

Aggradation

27. The project will be subject to some aggradation during the 25-year and larger peak discharges. If the 100-year peak discharge of 79,400 cfs (Table 2) is assumed to last one day, some 20,000 tons of material would be deposited between cross sections 10 and 11.5. Assuming this material is deposited evenly over this reach of the river, this relatively small amount of aggradation should not affect the integrity of the project. During the normal events and flood flow events less than the 25-year peak discharge, no significant aggradation should occur in the proposed levee project for the South Branch of the Potomac River at Petersburg, West Virginia.

Degradation

28. No degradation trends were found in the existing channel inverts during the field trip. Comparing the hydraulic properties of the existing channel to the proposed channel indicated general long-term degradation should

not occur in the proposed project. The Baltimore District has analyzed the channel for local erosion problems. Local erosion can be a problem at bridges, culverts, and transition points.

Maintenance and monitoring

29. The local sponsor will need to monitor the channel, including the approach and exit reaches, by resurveying established sediment ranges. Because of increased stages that will occur (Figure 3) during major floods, i.e., any in excess of the 10-year peak discharge, the channel should also be re-surveyed after each major flood event. The purpose of this re-survey would be to determine if any general or localized degradation has occurred in the channel. Perhaps the sediment ranges could be located during the project design and monumented as a part of the construction contract. A procedure for monitoring the channel should be documented in the operations and maintenance manual for the project. Photographs of the desired channel will aid the local sponsor in knowing when to remove vegetation so design n values and constraints are not being violated.

Table 1

Annual Flow-Duration Table South Branch Potomac River at Petersburg

Percent of Time Q is Equaled or exceeded	Q cfs
0	78,000
0.005	77,000
0.009	30,000
0.013	20,000
0.06	15,000
5.00	2,450
10.00	1,620
15.00	1,225
20.00	1,000
30.00	680
40.00	500
50.00	360
60.00	260
70.00	190
80.00	130
90.00	93
94.00	80
100.00	40

Table 2

Annual Peak Discharges in CFS for South Potomac River at Petersburg (Cross Section 10) for the Existing Channel and Project Channel

2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	SPF
15,480	24,400	32,600	47,900	61,600	79,400	155,000

Table 3

Sediment Discharge Rating Curve

Inflowing Load

Cross-Section 17

Q cfs	Top Width ft	Normal Depth ft	EFF Depth ft	EFF Width ft	VEL fps	TAU psf	Sediment* Load in Tons/Day
100	111.0	0.80	0.67	87	1.62	0.128	1
1000	191.0	2.16	1.71	158	3.57	0.323	43
2000	215.2	2.93	2.39	176	4.59	0.450	119
4000	249.6	4.01	3.33	197	5.82	0.626	312
6110	277.2	4.88	4.06	215	6.66	0.763	554
8000	297.8	5.54	4.59	228	7.24	0.863	805
15480	360.0	7.52	6.13	269	8.81	1.151	1905
20000	362.5	8.39	6.84	288	9.65	1.283	2796
24400	364.6	9.16	7.49	301	10.37	1.404	3834
32600	368.2	10.45	8.62	317	11.54	1.614	5999
155000	2663.8	16.98	9.53	1375	10.54	1.831	19679

* Sediment weight is 120 pcf.

Table 4

Sediment Discharge Rating Curve South Branch

Potomac River Existing Conditions

Q cfs	Top Width ft	Normal Depth ft	EFF Depth ft	EFF Width ft	VEL fps	TAU psf	Sediment* Load in Tons/Day
			Cross-Section 10				
100	129.8	1.02	0.65	93	1.55	0.124	1
1000	171.6	2.36	1.81	144	3.73	0.340	46
2000	180.2	3.16	2.54	158	4.87	0.477	133
4000	185.1	4.34	3.64	169	6.39	0.682	368
6110	187.9	5.32	4.57	174	7.55	0.856	709
8000	188.0	6.08	5.30	178	8.40	0.992	1052
15480	188.0	8.54	7.69	183	10.95	1.437	2822
20000	188.0	9.79	8.91	184	12.14	1.665	4142
155000	2929.8	17.72	9.99	1335	9.86	1.958	15372
			Cross-Section 11.5				
100	47.5	1.04	0.99	42	2.34	0.186	1
1000	99.0	3.34	2.93	62	5.17	0.552	65
2000	147.8	4.53	3.75	81	5.88	0.709	135
4000	223.3	5.96	4.57	116	6.59	0.862	297
6110	277.3	6.99	5.09	147	7.07	0.959	492
8000	315.5	7.72	5.44	172	7.41	1.024	687
15480	342.2	9.64	6.58	239	8.98	1.232	1825
20000	349.2	10.56	7.26	262	9.80	1.356	2711
24400	359.0	11.36	7.89	277	10.50	1.472	3723
32600	373.8	12.69	8.97	298	11.60	1.673	5788
155000	3676.4	15.87	7.63	2569	7.22	1.372	10140

* Sediment weight is 120 pcf.

Table 5

Sediment Discharge Rating Curve South Branch

Potomac River Project Conditions

Q cfs	Top Width ft	Normal Depth ft	EFF Depth ft	EFF Width ft	VEL fps	TAU psf	Sediment* Load in Tons/Day
			Cross-Section 10				
100	129.8	1.02	0.65	93	1.55	0.124	1
1000	171.6	2.36	1.81	144	3.73	0.340	46
2000	180.2	3.16	2.54	158	4.87	0.477	133
4000	185.1	4.34	3.64	169	6.39	0.682	368
6110	187.9	5.32	4.57	174	7.55	0.856	709
8000	188.0	6.08	5.30	178	8.40	0.992	1052
15480	188.0	8.54	7.69	183	10.95	1.437	2822
20000	188.0	9.79	8.91	184	12.14	1.665	4142
24400	233.1	10.76	9.68	196	12.51	1.816	4962
155000	645.2	23.13	17.69	462	17.58	3.321	41233
			Cross-Section 11.5				
100	47.5	1.04	0.99	42	2.34	0.186	1
1000	99.0	3.34	2.93	62	5.17	0.552	65
2000	147.8	4.53	3.75	81	5.88	0.709	135
4000	223.3	5.96	4.57	116	6.59	0.862	297
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20000	349.2	10.56	7.26	262	9.80	1.356	2719
24400	359.0	11.36	7.89	277	10.50	1.472	3735
32600	373.8	12.69	8.97	298	11.60	1.673	5788
79400	3555.0	**	8.45	2817	3.3		356
155000	3723.0	**	13.48	3473	3.3		1

* Sediment weight is 120 pcf.

** Due to backwater, the normal depth is not applicable at this flow for this cross section. (Water-surface elevations were taken from HEC-2 profiles, Plan 4.)

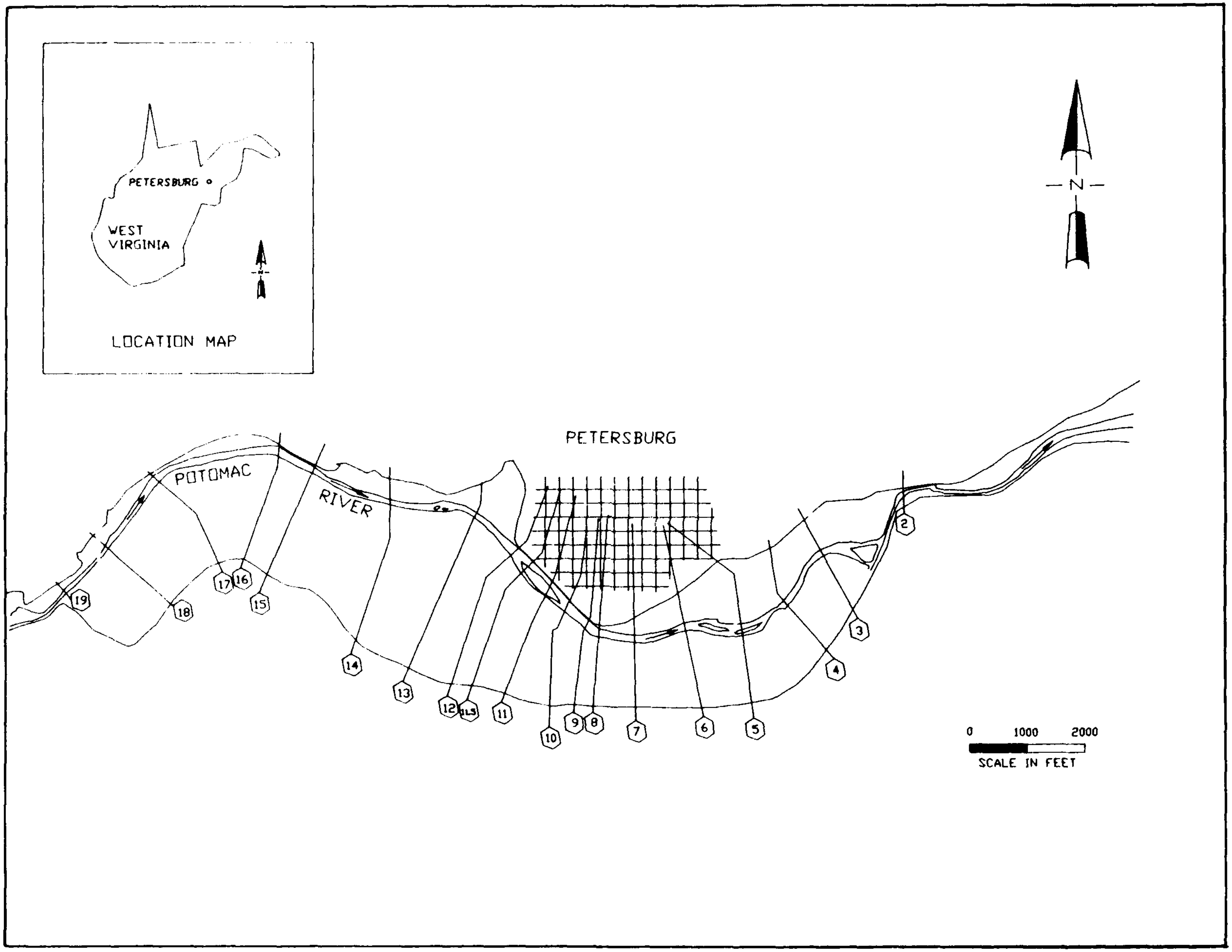
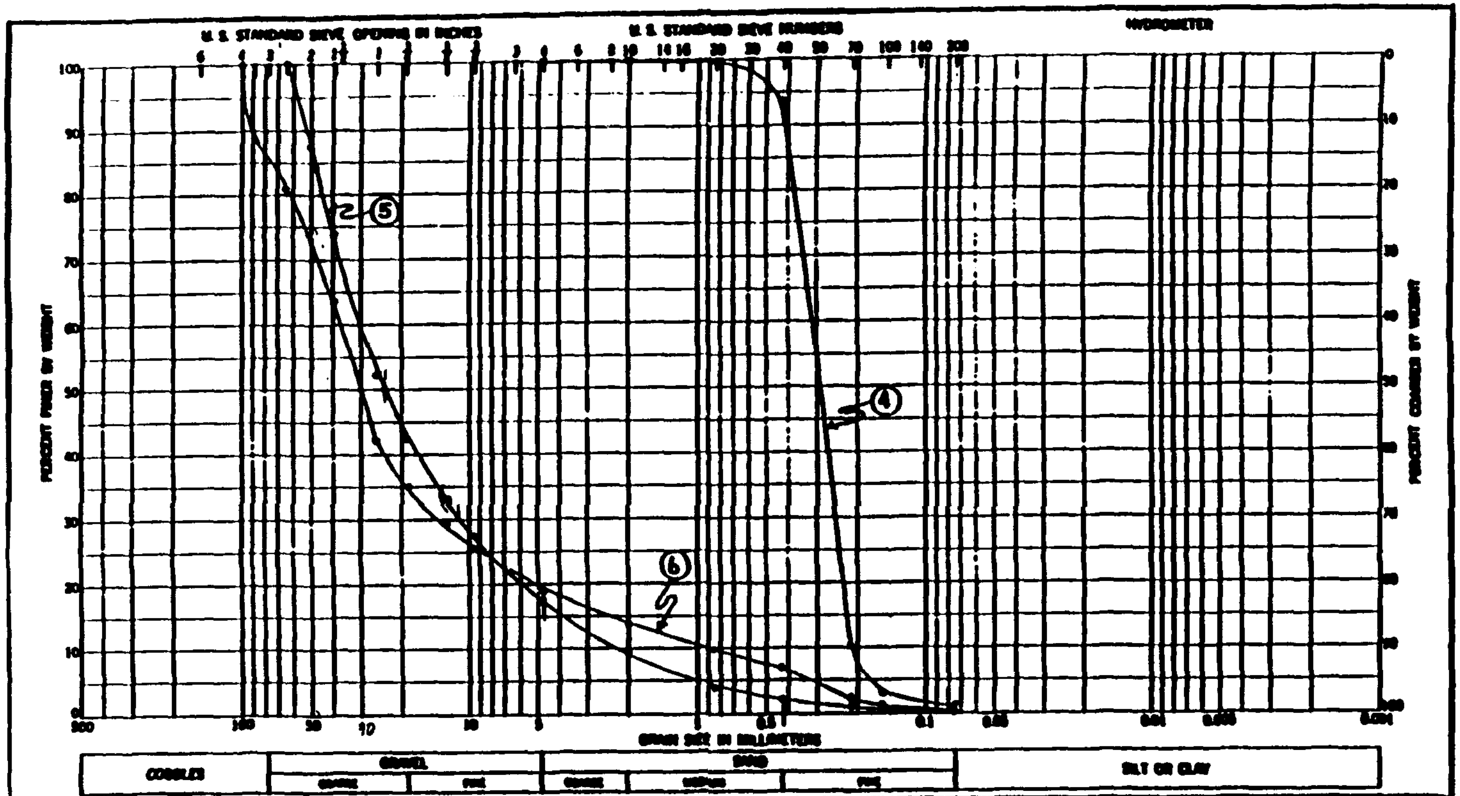


Figure 1. Location map



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
S.B.-4		Fine sand (SP)				
S.B.-5		Sandy gravel (GW)				
S.B.-6		Sandy gravel (w/cobble) (GP)				

Project: Bed Samples - South Branch of the Potomac River

Area: Petersburg, W.VA.

Boring No.

Date: Sep. 1988

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure 2. Gradation curves

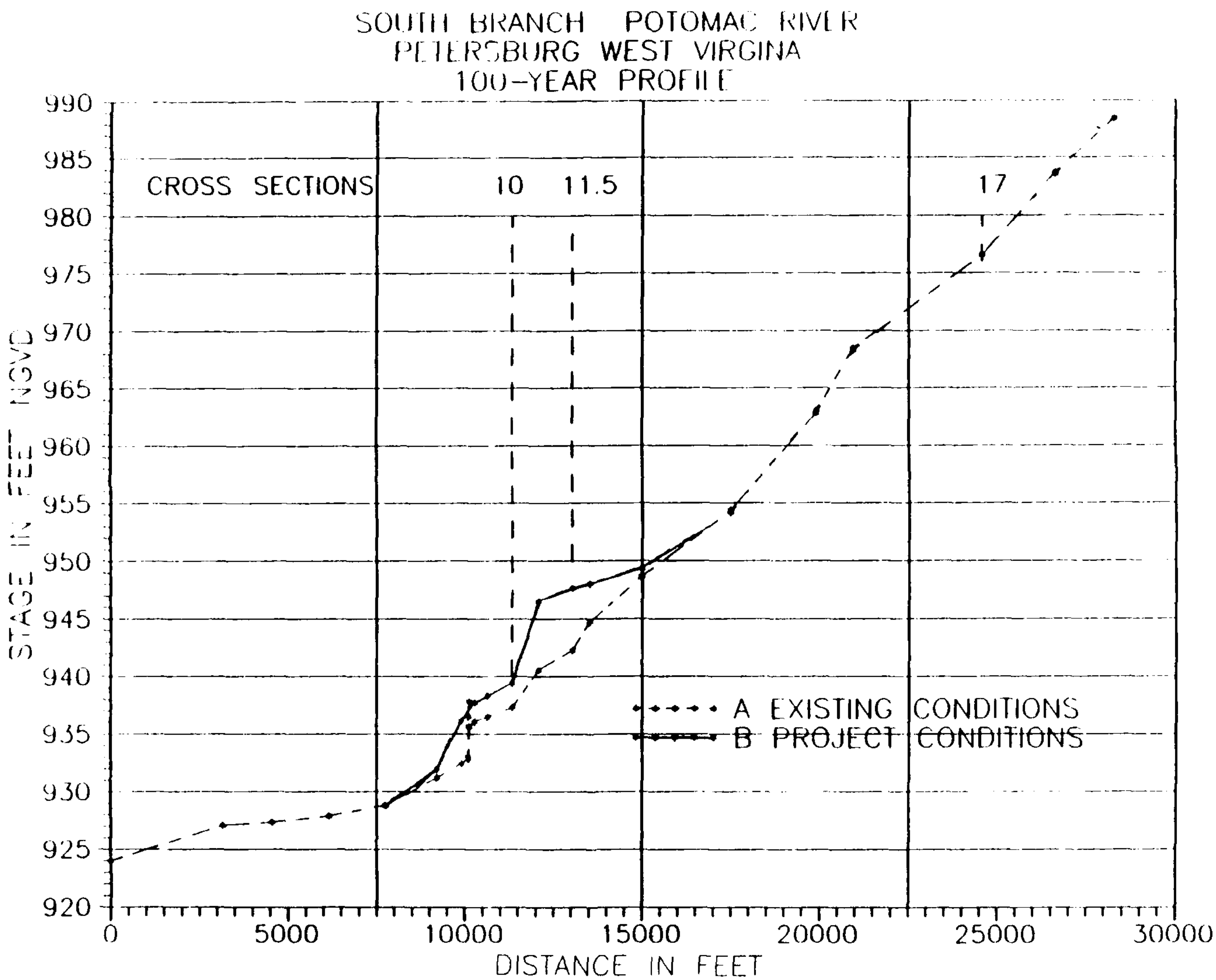


Figure 3. 100-year flood profile

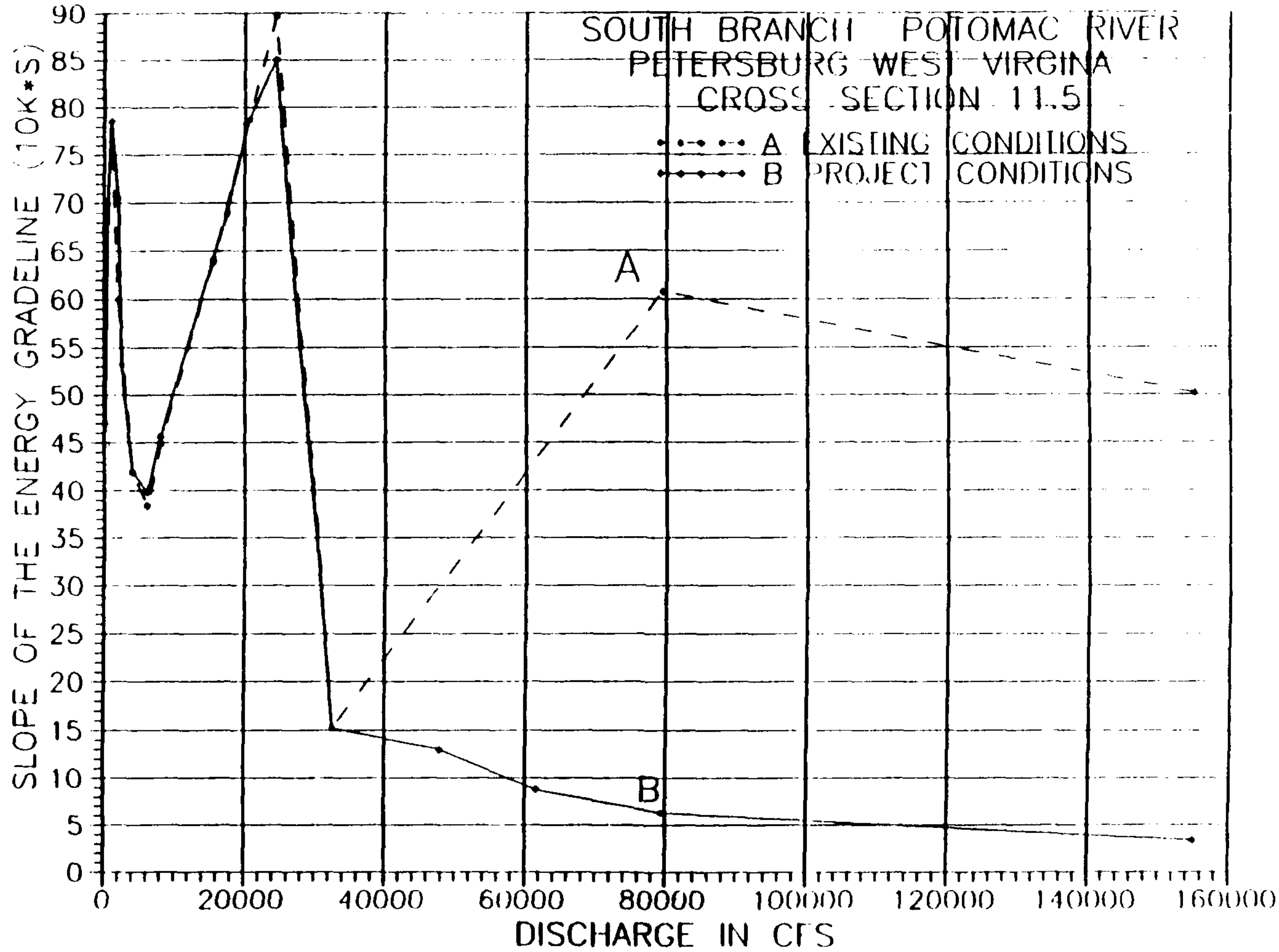


Figure 4. Water surface slope at cross section 11.5 for existing and project conditions

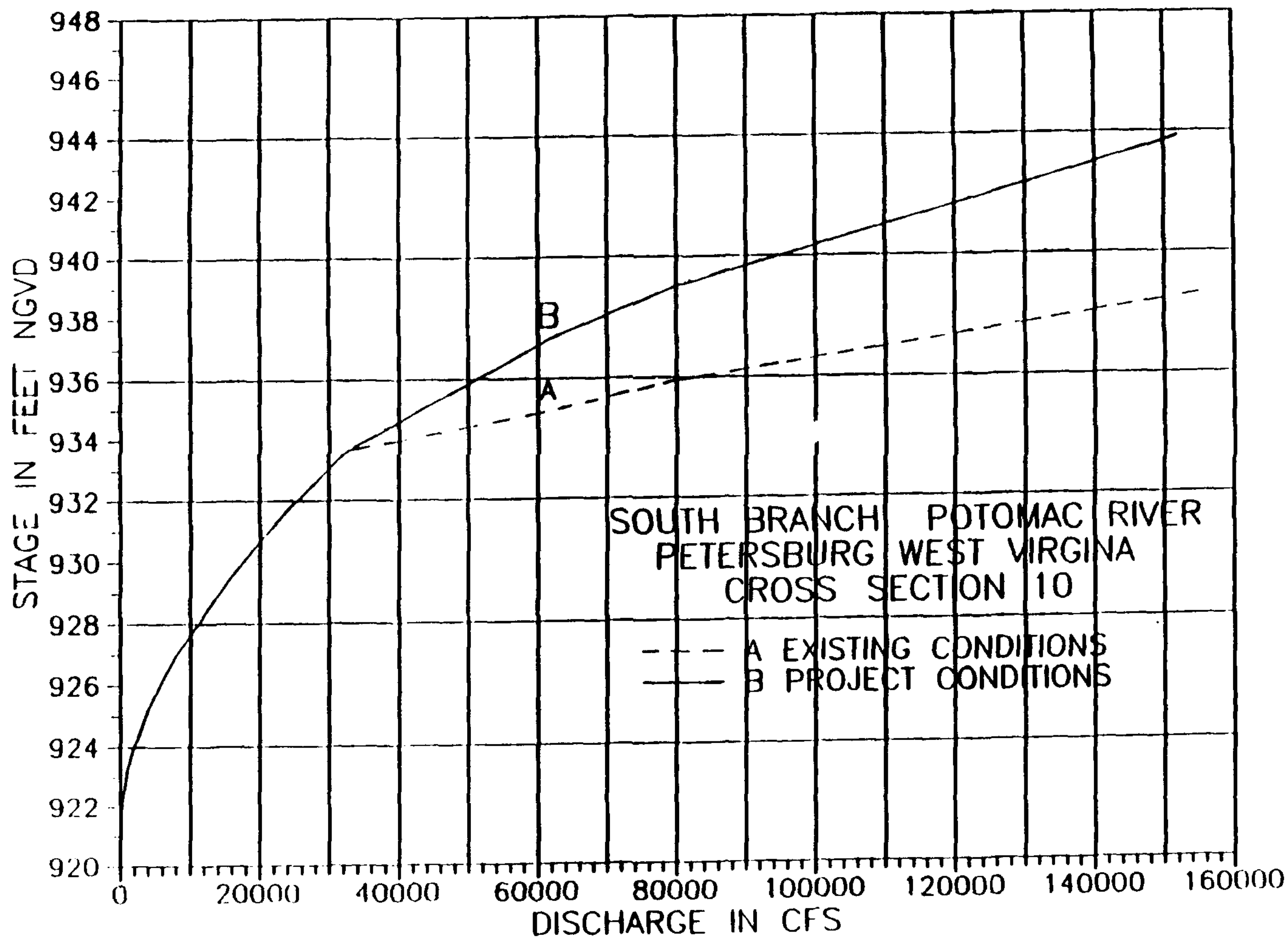


Figure 5. Stage-discharge relation for cross section 10

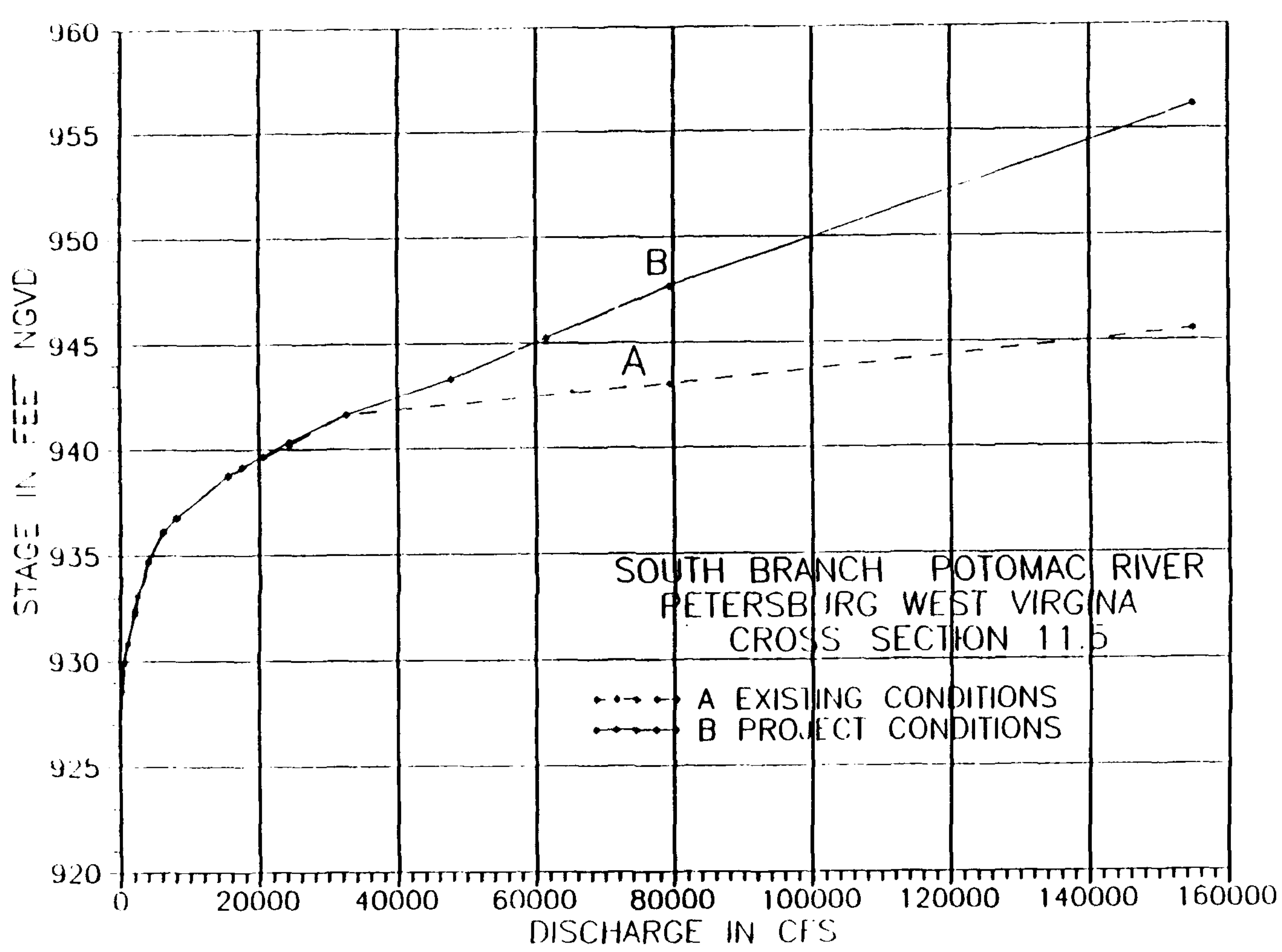


Figure 6. Stage-discharge relation for cross section 11.5

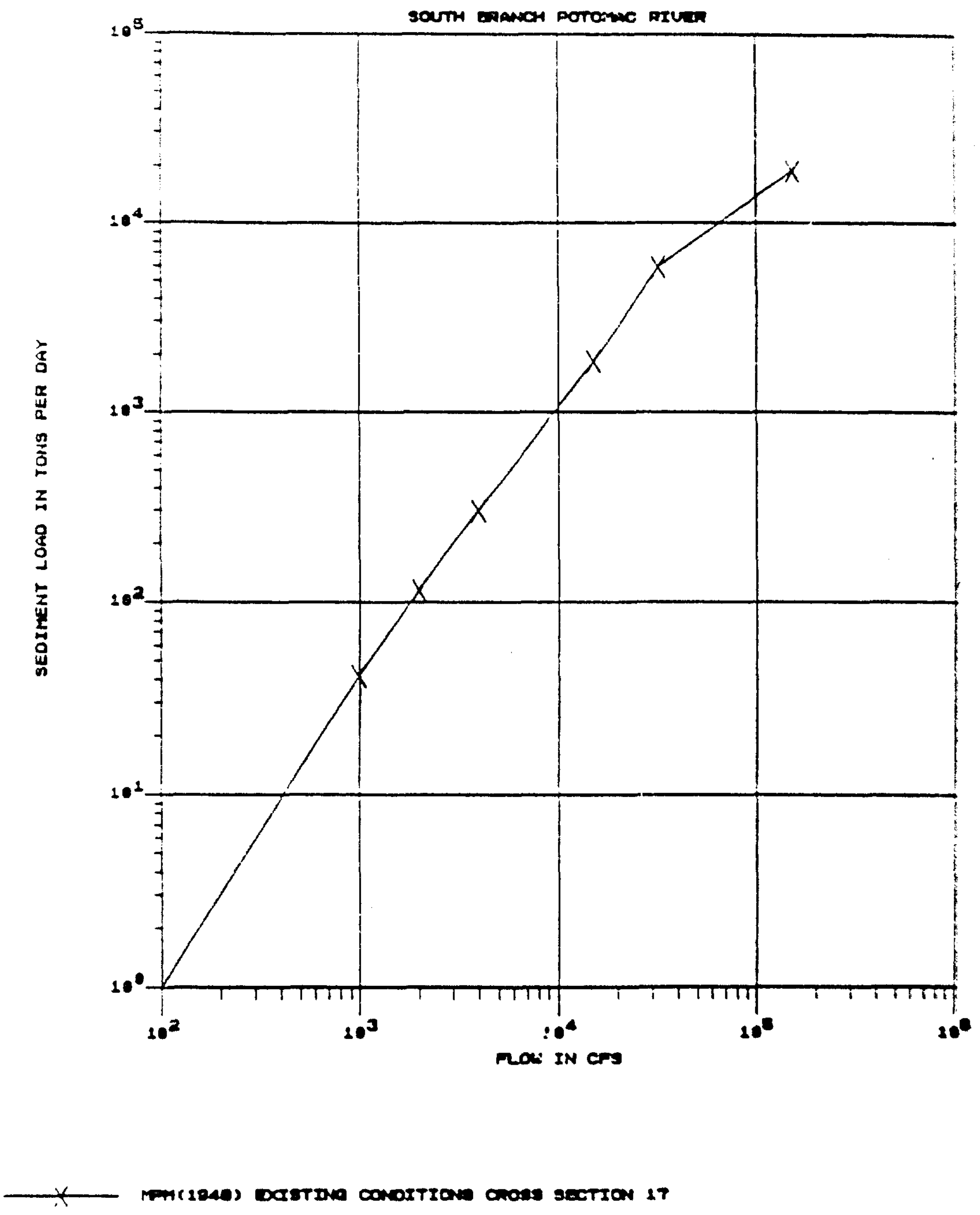


Figure 7. Existing condition sediment load at cross section 17

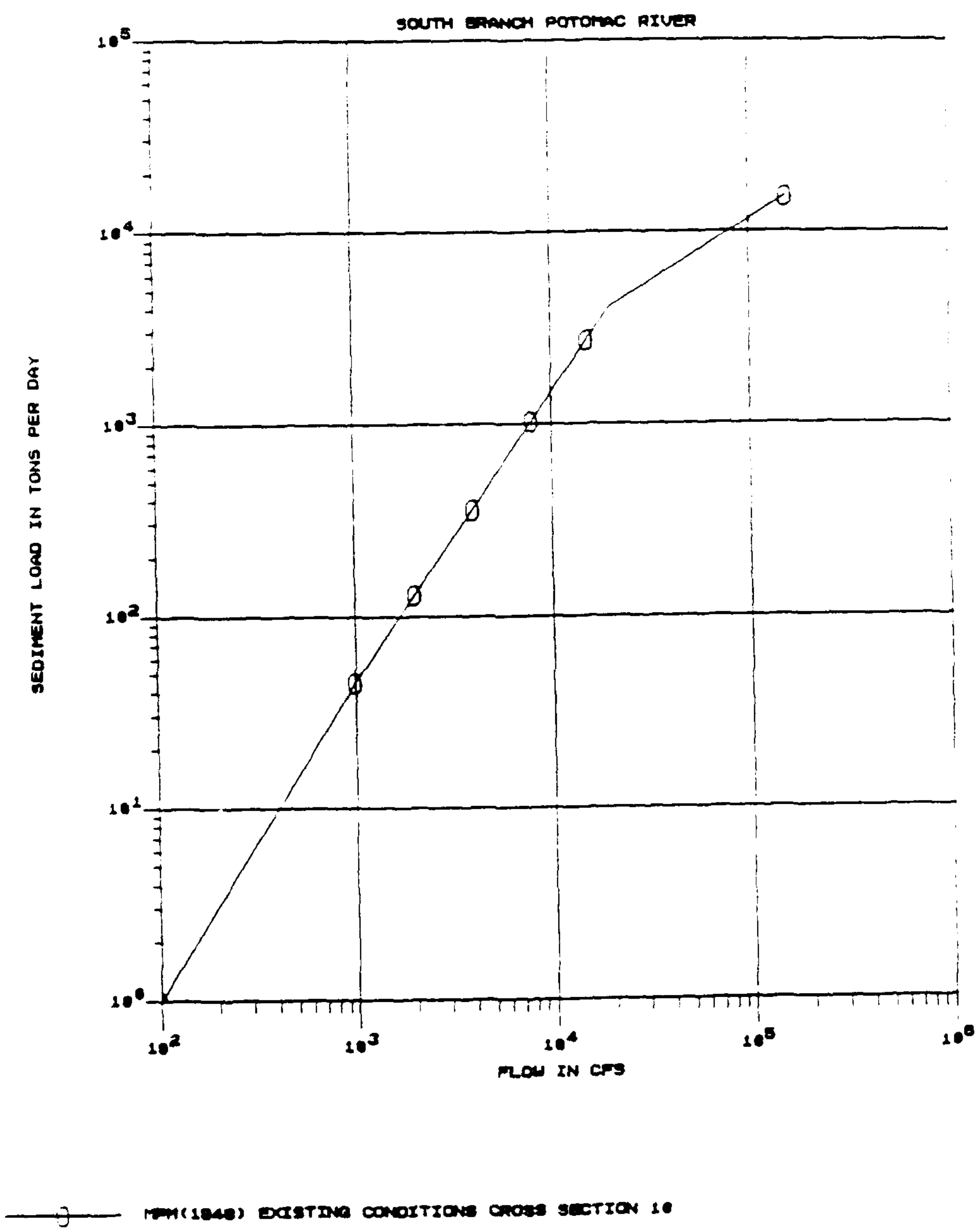


Figure 8. Existing condition sediment load at cross section 10

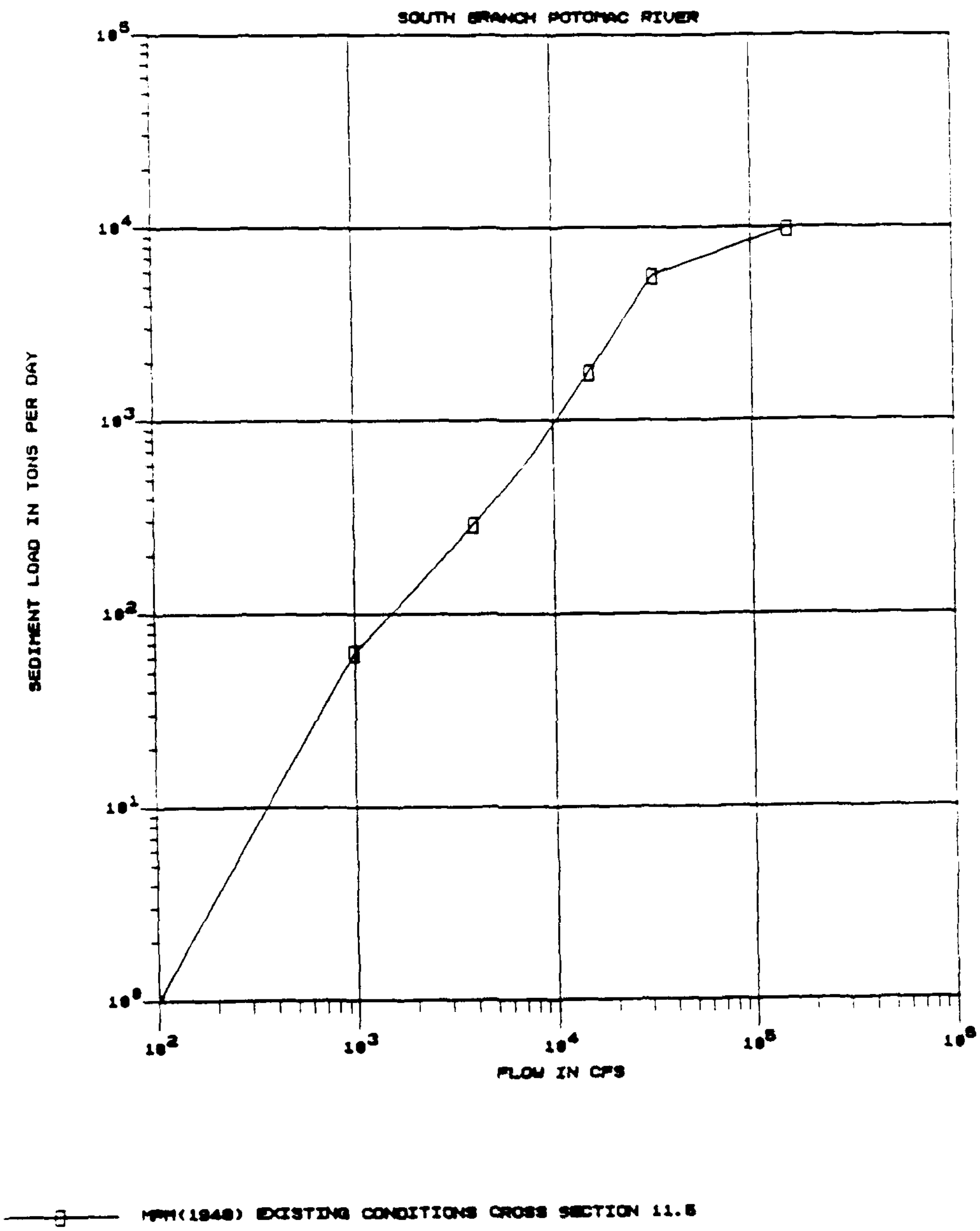


Figure 9. Existing condition sediment load at cross section 11.5

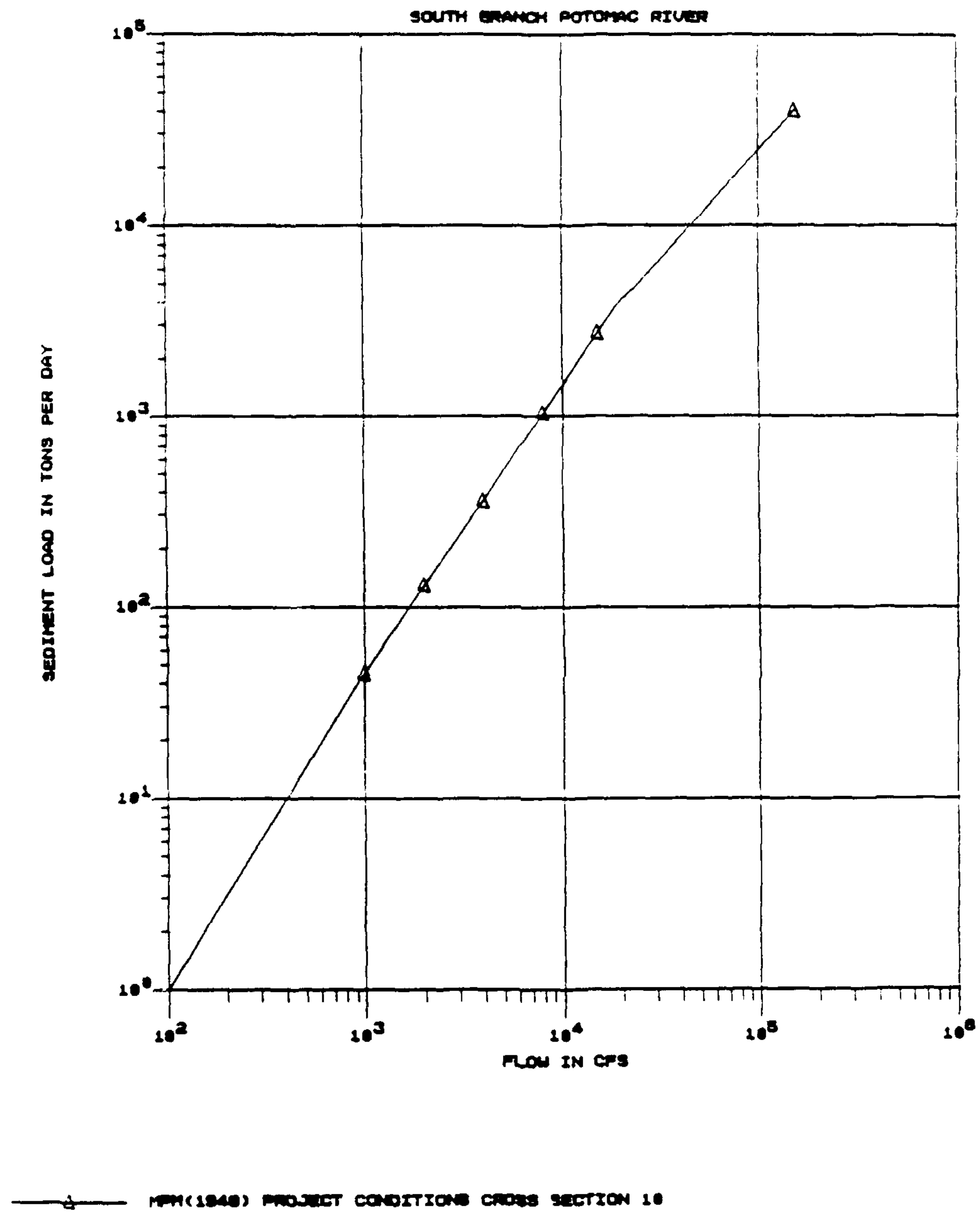


Figure 10. Sediment versus water discharge, project condition, cross section 10

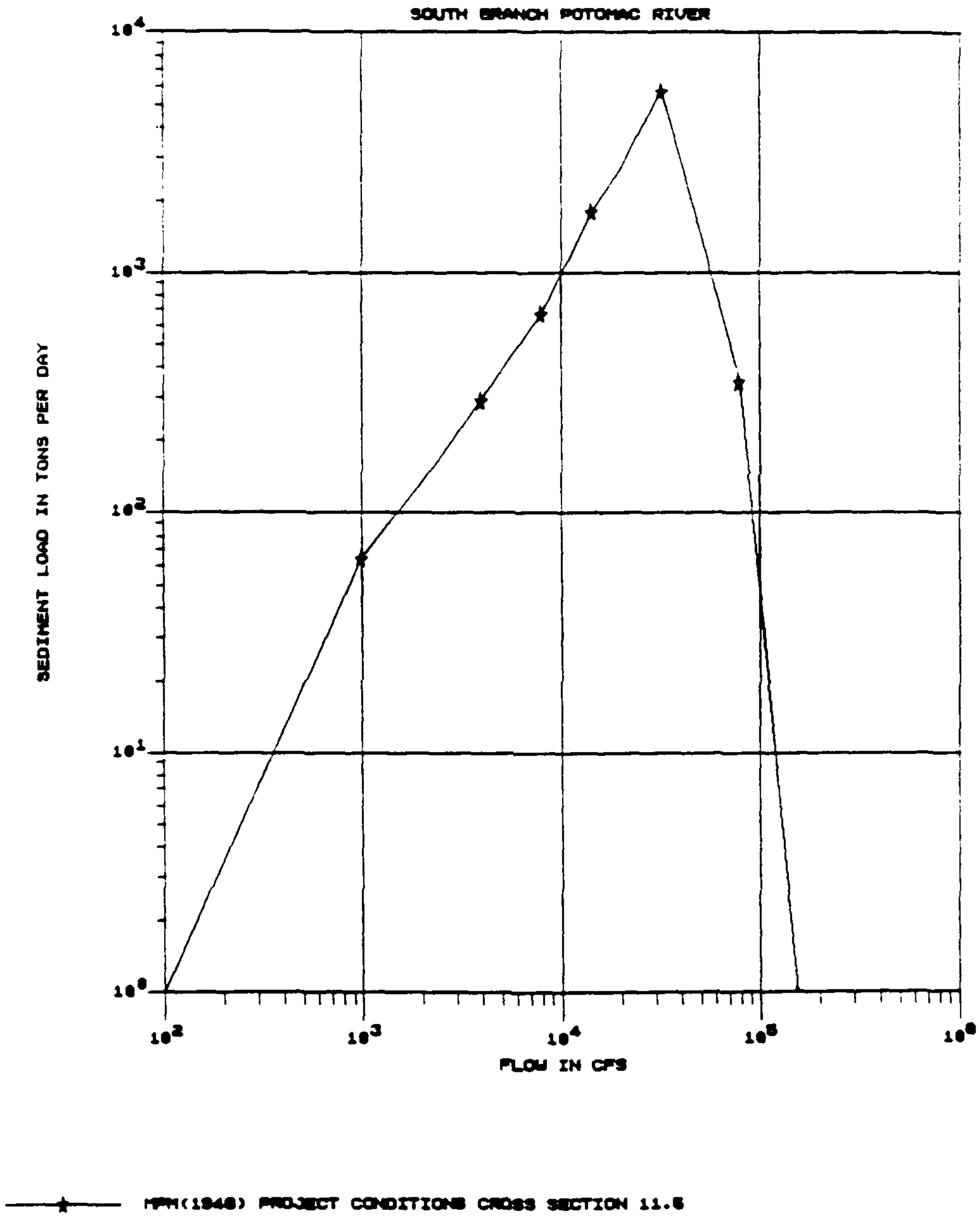


Figure 11. Sediment versus water discharge, project condition, cross section 11.5